LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

LEVEL

INVENTORY

0

DTIC ACCESSION NUMBER

Two-Year Soil Gas Sampling + Respiration...

DOCUMENT IDENTIFICATION

14 Dec 98

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR
NTIS GRA&I
DTIC TRAC
UNANNOUNCED
JUSTIFICATION

BY

DISTRIBUTION/

AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

20001122 043

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

HANDLE WITH CARE

DTIC FORM 70A JUN 90

DOCUMENT PROCESSING SHEET

LOAN DOCUMENT

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

DTIC QUALITY INSPECTED 4

PARSONS

Parsons Engineering Science, Inc.
1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208

December 14, 1998

Mr. Jerry Branum
AFBCA/DA Eaker
2809 Atlanta St.
Eaker AFB, AR 72315

Subject: Two-Year Soil Gas Sampling and Respiration Testing Results for the Bioventing System at Spill Site No. 1, Eaker AFB, Arkansas (Contract No. F41624-92-8036, Order 17)

Dear Mr. Branum:

This letter presents the results of the static soil gas sampling and respiration testing performed by Parsons Engineering Science, Inc. (Parsons ES) at Spill Site No. 1, Eaker Air Force Base (AFB), Arkansas. Soil gas samples were collected and *in situ* respiration testing was performed by Parsons ES from September 11 through 14, 1998 to assess the extent of remediation completed during approximately 2 years of air injection bioventing. The purpose of this letter is to summarize site and bioventing activities to date, present the results of the most recent respiration testing and soil gas sampling event, and to compare these results with previous pilot testing and monitoring results. A site layout and two tables are attached. The as-built bioventing system and soil gas sampling/respiration testing locations are illustrated on Figure 1. Table 1 provides initial, 1-year, and 2-year soil gas sampling results. Table 2 provides the results of respiration testing performed prior to bioventing system startup, and after 1 and 2 years of air injection bioventing.

SITE/PROJECT HISTORY

Site Description

Spill Site No. 1, also referenced to as Area-of-Concern (AOC) No. 4, is located near former Pumphouse No. 4 (former Building 1020), between former Pumphouse No. 2 and the southeastern terminus of the flight apron (Figure 1). Four 50,000-gallon underground storage tanks (USTs) containing jet propulsion grade 4 (JP-4), and one 2,000-gallon JP-4 waste collection UST were formerly located northeast and southeast of Pumphouse No. 4. Ten- and 6-inch pipelines were used to transfer fuel from the four tanks to the aircraft fueling hydrants on the flight apron. Pressure testing of the fuel hydrant system, performed in 1973, indicated the presence of a leak in the 6-inch fuel line, northwest of Pumphouse No. 4, and the system was taken out of service. During the subsequent pipeline repair, petroleum-contaminated soils were observed in

DEFENSE TECHNICAL INFORMATION CENTER
REQUEST FOR SCIENTIFIC AND TECHNICAL REPORTS

Title AFCEE Collection

1. Report Availability *(Please check one box)*

☒ This report is available. *Complete sections 2a - 2f.*

☐ This report is not available. *Complete section 3.*

2a. Number of Copies Forwarded 1 each

2b. Forwarding Date July/2000

2c. Distribution Statement *(Please check ONE box)*

DoD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly below. Technical documents MUST be assigned a distribution statement.

☒ DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

☐ DISTRIBUTION STATEMENT B: Distribution authorized to U.S. Government Agencies only.

☐ DISTRIBUTION STATEMENT C: Distribution authorized to U.S. Government Agencies and their contractors.

☐ DISTRIBUTION STATEMENT D: Distribution authorized to U.S. Department of Defense (DoD) and U.S DoD contractors only.

☐ DISTRIBUTION STATEMENT E: Distribution authorized to U.S. Department of Defense (DoD) components only.

☐ DISTRIBUTION STATEMENT F: Further dissemination only as directed by the controlling DoD office indicated below or by higher authority.

☐ DISTRIBUTION STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, 6 Nov 84.

2d. Reason For the Above Distribution Statement *(in accordance with DoD Directive 5230.24)*

2e. Controlling Office HQ AFCEE

2f. Date of Distribution Statement Determination 15 Nov 2000

3. This report is NOT forwarded for the following reasons. *(Please check appropriate box)*

☐ It was previously forwarded to DTIC on ..... *(date)* and the AD number is .....

☐ It will be published at a later date. Enter approximate date if known. .....

☐ In accordance with the provisions of DoD Directive 3200.12, the requested document is not supplied because:

.....

.....

.....

Print or Type Name Laura Peña

Signature Laura Peña

Telephone 210-536-1431

(For DTIC Use Only)
AQ Number M01-01-0328

the shallow excavation. The time frame and amount of fuel released are unknown. The USTs and Building 1020 were removed in September 1994, and the fuel lines were abandoned in place. The site is currently vacant and inactive.

Initial Site Investigation/RFI

Halliburton NUS (HNUS) has directed several site investigation activities at Spill Site No. 1. In 1988, as part of an Installation Restoration Program (IRP) Site Investigation (SI), HNUS (1990) installed and sampled three monitoring wells (MW201, MW202, and MW203) (Figure 1). From December 1991 through September 1995, field work associated with a Resource, Conservation, and Recovery Act (RCRA) Facility Investigation (RFI) was accomplished. During the RFI efforts, HNUS conducted a 35-point soil gas survey, installed eight additional groundwater monitoring wells (wells MW204 through MW211), drilled and sampled six boreholes (SB206 through SB211), and collected seven groundwater grab samples using a Geoprobe® (GW201 through GW207). The Final RFI Report (HNUS, 1997) was approved by the Arkansas Department of Pollution Control and Ecology (ADPC&E) in September 1997.

Results of the SI (HNUS, 1990) and RFI (HNUS, 1997) efforts indicated the presence of significant petroleum hydrocarbon contamination at the west side of former Pumphouse No. 4 (former Building 1020). High levels of benzene were detected in soil samples collected at boring SB208 and in a groundwater sample from monitoring well MW211.

Parsons ES Investigations and Bioventing System Installation/Monitoring

In March and April 1996, Parsons ES installed a pilot-scale bioventing system at the Spill Site No. 1 to assess the potential of air injection bioventing for remediating the petroleum hydrocarbon contamination identified in vadose zone and smear zone soils. The bioventing system was installed in the area of contaminated soils located northwest of the former Building 1020, and consisted of five vent wells (VWs) (VW1 through VW5), five vapor monitoring points (MPs) (MPA through MPE), one Geoprobe® soil boring (SB6), and a 2-horsepower regenerative blower system. One existing groundwater monitoring well (MW205) was plumbed to the blower system, and was designated as air injection VW6. Figure 1 shows the site layout with the locations of the bioventing system components.

During installation of the pilot-scale system, soil and soil gas sampling, and respiration and air permeability testing were performed. Based on oxygen influence and air permeability testing performed during installation of the pilot-scale system, the long-term radius of oxygen influence around the VWs was expected to exceed 32 feet at depths below 5 feet bgs. From this information, it was determined that the multiple-well bioventing system was capable of delivering oxygen throughout vadose zone soils in the source area. A detailed description of the pilot-scale bioventing system design and initial testing results are provided in the Interim Pilot Test Results report prepared by Parsons ES (1996) for this site.

Following completion of the multiple-well pilot-scale system installation and testing, the system was started, optimized, and operated almost continuously for 13 months. In May 1997, Parsons ES conducted oxygen influence monitoring at the site to confirm that the targeted soil zone was being provided with an adequate supply of oxygen. Following oxygen influence monitoring, the system was shut down for 1 month to allow soils and soil gas to come to equilibrium in order to compare initial and 1-year conditions. Soil gas samples were collected and *in situ* respiration testing was performed from 15 June through 21 June 1997 following 13 months of system operation (Parsons ES, 1997).

To further define the extent of contamination and to evaluate the potential for remediation by natural attenuation (RNA) of dissolved organics in groundwater, soil and groundwater samples were also collected at the site during the June 1997 field event. Parsons ES advanced five Geoprobe® soil borings (MPF, MPG, MPH, MPI, and SB7) to varying depths corresponding to the smear zone (the zone of petroleum hydrocarbon contamination in soil associated with the surface of the groundwater). Single-depth vapor MPs were constructed in four of the Geoprobe® borings (MPF-8.5, MPG-6, MPH-8, and MPI-8). Parsons ES also collected five groundwater samples from existing wells MW204, MW206, MW207, MW208, and MW211, and one sample from background well MW010. Groundwater samples were analyzed in the field for electron acceptors and other geochemical parameters to assess the degree of natural attenuation occurring in groundwater at the site. On June 20, 1997, the blower system was restarted following the 1-year testing to continue bioventing treatment of site soils. Initial and 1-year soil and soil gas sampling results, groundwater sampling results, and respiration testing results were provided by Parsons ES (1997) to AFCEE and Eaker AFBCA.

In early September 1997, the 2-HP regenerative blower at Spill Site No. 1 ceased to operate, and was replaced with a larger 3-HP regenerative blower unit. The site was not being treated during the period between early September and early November 1997, and during other time periods when power outages would shut off the system. Cumulatively, between April 1996 and September 1998, the bioventing unit had operated for approximately 2 years. Until regulatory closure has been achieved and the bioventing system has been removed, weekly system checks should be performed to ensure that the blower is operational.

In August 1998, the bioventing system was shut down for 1 month to allow development of equilibrium conditions in site soils and soil gas for the 2-year testing event. Soil gas sampling and *in situ* respiration testing were performed from 11 through 14 September 1998, as described in Section 4.2 of the Final Confirmation Sampling and Analysis Plan for Spill Site No. 1 (Parsons ES, 1998). Results of the 2-year soil gas sampling and respiration testing event are presented in this report.

Following 2-year testing, confirmation soil and groundwater sampling activities were performed by Parsons ES in accordance with Section 4 of the Final Confirmation Sampling and Analysis Plan for Spill Site No. 1 (Parsons ES, 1998). Results of the

confirmation soil sampling event will be provided under separate cover in a forthcoming report. Following confirmation sampling, the blower system was restarted to continue bioventing treatment of site soils.

Corrective Measures Study

TetraTech NUS (formerly Halliburton NUS) prepared a Draft Final Corrective Measures Study (CMS) report for Spill Site No. 1 (AOC No. 4) that was submitted to ADPC&E for review in August 1998 (TetraTech NUS, 1998). To date, the ADPC&E has not provided comments on the draft final CMS. The draft final CMS recommended that the site be evaluated after completion of the September 1998 bioventing system monitoring and confirmation sampling event performed by Parsons ES. Information provided and recommendations made in this letter report may be used by TetraTech NUS in the development of a Corrective Measures Implementation Plan, that will be submitted to ADPC&E once the CMS is approved.

SOIL GAS CHEMISTRY RESULTS

Field screening and collection of soil gas samples for laboratory analysis were performed on 11 and 12 September 1998, following approximately 1 month of system shutdown. Soil gas samples were collected from VW2, VW6, all of the MP screened intervals except for MPG-6 (which could not be located in the field), and several groundwater monitoring wells, and field-screened to assess soil gas concentrations of oxygen, carbon dioxide, and total volatile hydrocarbons (TVH) following approximately 2 years of bioventing operation. In addition, soil gas samples for laboratory analysis were collected from eight MP screened intervals (MPA-9, MPB-5, MPB-8.5, MPC-5, MPC-9, MPD-5, MPD-9, and MPE-9.5). The laboratory soil gas sample at MPB-5 was collected to verify the field TVH reading and to verify that vadose zone soils in the vicinity of this sampling location were remediated, since TVH readings in previous sampling events at MPB-5 were elevated. All other laboratory soil gas samples were collected to determine point-specific contaminant reductions that had been achieved through bioventing. For all soil gas sampling events discussed in this report, laboratory samples were sent to Air Toxics, Ltd. in Folsom, California and analyzed for TVH and benzene, toluene, ethylbenzene, and xylenes (BTEX) using US Environmental Protection Agency (USEPA) Method TO-3. Field and laboratory soil gas sampling results from March 1996, June 1997, and September 1998 are presented in Table 1 (attached).

High static oxygen concentrations detected in soil gas from one VW (VW2), two MP screens (MPB-5 and MPC-5), and several groundwater monitoring wells indicate that there are no significant amounts of aerobically biodegradable hydrocarbons present in soils at these locations, and that the rate of oxygen diffusion into these soils exceeds the rate at which oxygen is consumed by soil bacteria. The soil gas sample from VW2 contained oxygen at 13.3 percent, which is a significant increase from the initial, pre-treatment concentration of 0 percent. At MPB-5 and MPC-5, oxygen was detected at concentrations of 17.3 and 15.0 percent, respectively, indicating that vadose zone soils

do not contain significant concentrations of hydrocarbons at these locations. Soil gas samples collected from groundwater monitoring wells at Spill Site #1 contained oxygen at concentrations ranging from 8.1 to 20.8 percent, indicating either that aerobic hydrocarbon biodegradation rates have either slowed at these locations (at MW201, MW202, MW203, and MW207, where static oxygen concentrations have increased with time), or that soils have not been contaminated with petroleum hydrocarbons (at MW204, MW206, and MW211, where static concentrations have exceeded 18 percent in every sampling event). Leakage may have occurred during sampling at MW202 and MW203, and results shown for these two points may not be representative of actual subsurface conditions.

Low static oxygen concentrations detected in soil gas from one VW (VW6) one shallow MP screen (MPD-5), and several MP screens installed in smear zone soils at depths between 8.5 and 9.5 feet bgs indicate that significant concentrations of aerobically biodegradable hydrocarbons remain in soils at these locations, and that the soils will benefit from continued air injection bioventing. At VW6, the static oxygen concentration was still at a relatively low concentration of 3.3 percent. Soil gas samples collected from MP screens installed at depths between 8.5 and 9.5 feet bgs contained oxygen at concentrations of 5.8 percent or less, indicating that aerobic hydrocarbon biodegradation is still occurring at significant rates in the smear zone soils that occur at this depth. At MPD-5, soil gas conditions were anoxic, indicating that significant oxygen consumption still occurs in vadose zone soils in this area.

Since the last sampling event in June 1997, field soil gas TVH concentrations have decreased at all MPs except MPD-5, MPD-9, MPH-8, MPI-8, and MW207 (Table 1), which are all located on the periphery of the area being treated by the bioventing system (Figure 1). Laboratory soil gas TVH and BTEX concentrations have also decreased at all sampling locations since June 1997, except at MPD-9. The greatest contaminant reductions were observed at MPC-5, where laboratory TVH was reduced by 99.3 percent and total BTEX was reduced by 98.7 percent over a 1-year treatment period (between June 1997 and September 1998). Based on the increased field TVH concentrations and reduced oxygen concentrations observed at MPB-5 and MPC-5 during the 1-year sampling event, it appeared that volatile contaminants originating in the smear zone (located between 8 and 11 feet bgs) were being driven upward into a shallow clay zone (located at depths of 4 to 7.5 feet bgs) through air injection bioventing. The 2-year laboratory TVH and BTEX data at MPB-5 and MPC-5 indicate that hydrocarbon vapors are no longer being driven into shallow soils at significant concentrations, likely because the residual contaminant concentrations in the smear zone have decreased, and vapors that were forced into shallow soils during the June 1997 sampling event have been significantly reduced via aerobic biodegradation and other natural processes.

The greatest reductions at smear zone MP screens were observed at MPB-8.5 and MPE-9.5, where field TVH was reduced by at least 99.6 percent and 95.3 percent, respectively, over a 2-year treatment period. Comparing initial and 2-year laboratory TVH results for MPA-9 and MPC-9, TVH was reduced by 90.5 percent and 77.5

percent, respectively. The distribution of soil gas oxygen and TVH concentrations indicates that residual fuel contamination throughout the site is primarily limited to a thin smear zone associated with the fuel-impacted groundwater surface, and to areas located beyond the effective radius of oxygen influence of the bioventing system (near the abandoned fuel pipeline and adjacent to MPD, MPH, and MPI). Depleted soil gas oxygen concentrations measured in the smear zone indicate that aerobic hydrocarbon biodegradation rates remain high and exceed the rate at which oxygen can naturally diffuse into the soil from the ground surface and adjacent uncontaminated areas. Natural diffusion of oxygen into site soils is greatly restricted due to the presence of a low-permeability clay layer (located between 3 and 7.5 feet bgs) above the smear zone. Bioventing treatment of these smear zone soils has been limited and is much more effective when these soils become less moist during periods of low water table conditions. The depth to groundwater at VW2 was measured at 13.1 feet bgs in March 1996, and at 12.3 feet bgs in September 1998. During the 2-year sampling event in September 1998, the groundwater surface was encountered at depths of approximately 12.5 to 14 feet bgs. Groundwater was encountered at approximately 0.5 to 1 foot deeper during April 1996.

Field and analytical soil gas results suggest a significant degree of remediation has occurred in the unsaturated soils at Spill Site No. 1. The overall increases in soil gas oxygen concentrations, and lower TVH and BTEX concentrations in soil gas samples collected above the smear zone indicate that fuel hydrocarbons in these soil have been reduced considerably. However, soil gas field and laboratory analytical results also indicate that high concentrations of petroleum hydrocarbon contamination persist in smear zone soils at the site.

IN SITU RESPIRATION TEST RESULTS

In situ respiration (oxygen utilization) tests can be used as a qualitative guide to determine the degree of soil remediation that has been achieved due to aerobic biodegradation. Field respiration testing has been conducted three times during bioventing implementation at Spill Site No. 1. The initial testing event was associated with the initial bioventing system installation and was conducted in March 1996 (prior to system startup). The second test (referred to as the 1-year event) was performed in June 1997, after 13 months of bioventing system operation. The third respiration testing event (referred to as the 2-year event) was conducted in September 1998, following 1 month of blower shut down of the bioventing system. Observed rates of oxygen utilization were used to estimate aerobic fuel biodegradation rates for each respiration test. Initial, 1-year, and 2-year *in situ* respiration and fuel biodegradation rates for site soils are shown on Table 2.

The 1998 *in situ* respiration testing was performed at Spill Site No. 1 during 12 through 14 September 1998. Point respiration tests were conducted at MPA-9, MPB-8.5, MPC-9, MPD-9, and MPE-9.5. The tests were performed according to protocol procedures (Hinchee *et al.*, 1992). The point respiration tests were performed by injecting air (oxygen) into each MP screened interval for a 23 to 40-hour period using a

1-cubic-foot-per-minute (cfm) pump. After the pump was turned off, changes in soil gas chemistry at each MP were measured for at least 1 day.

As can be seen from Table 2, compared to initial and 1-year rates, a significant reduction occurred in the oxygen utilization and fuel biodegradation rates at MPA-9 and MPB-8.5 following 2 years of bioventing system operation. At MPC-9 and MPD-9, respiration and corresponding fuel biodegradation rates have increased significantly since the start up of bioventing system, indicating that significant concentrations of petroleum hydrocarbons are still present at these locations. The increases in the September 1998 oxygen utilization rates may be caused by a higher overall soil moisture content during this testing event. At MPE-9.5, which was not previously tested, the calculated biodegradation rate was 1,100 mg/kg/year. During September 1998, fuel biodegradation rates ranged from 250 mg/kg/year at MPA-9, to 2,900 mg/kg/year at MPD-9 (Table 2).

Assumptions that are made for soil moisture and soil porosity greatly affect the calculated biodegradation rates. The soil moisture data obtained during the September 1998 confirmation sampling event is believed to be more representative of actual conditions at these testing locations than previously collected soil moisture data due to the depth at which the samples were collected. Sampling depths in the September 1998 soil sampling event ranged from 7.5 to 12 feet bgs, with a soil moisture of 17 percent being measured at CBA (adjacent to MPA) at 8 feet bgs. The soil moisture value used for the biodegradation calculations in the bioventing pilot test (Parsons ES, 1996) and the 1-year sampling event (Parsons ES, 1997) was 11 percent, which is an average from three samples collected at VW1 at 6.5 feet bgs, VW1 at 10 feet bgs, and MPC at 5.5 feet bgs. These depths differ significantly from the 8.5 to 9-foot depths at which the respiration tests were performed. Because more representative soil moisture data was obtained during the September 1998 confirmation sampling, the biodegradation rates reported in previous events (Parsons ES, 1996 and 1997) were recalculated in Table 2 using a higher moisture content (17 percent) and a higher soil porosity (0.35) to reflect the higher sand content observed in soils at the 8.5 to 9-foot depth.

Oxygen utilization and fuel biodegradation rates typically decrease with continued bioventing as the lighter, more readily biodegraded hydrocarbons are preferentially destroyed over more biologically recalcitrant, higher molecular weight hydrocarbons. As demonstrated by the soil gas results presented in Table 1 and, to a lesser extent the *in situ* respiration testing results presented in Table 2, fuel hydrocarbon concentrations have been significantly reduced at most vadose zone sampling locations, but sufficient hydrocarbons remain in the smear zone soils and vadose zone soils near the south end of the effective treatment area of the bioventing system to sustain moderate to high respiration rates.

CONCLUSIONS

Based on soil gas sampling and respiration testing results obtained following 2 years of bioventing system operation, fuel hydrocarbons in the vadose zone and smear zone soil at Spill Site No. 1 have been reduced. However, high concentrations of aerobically

biodegradable fuel hydrocarbons remain in site soils in localized areas within the smear zone, and in areas on the periphery of the effective treatment area of the bioventing system. Although overall reductions in soil gas TVH and BTEX concentrations have been significant following 2 years of bioventing treatment, continued bioventing treatment is recommended.

The September 1998 collection of confirmation soil and groundwater samples indicates that benzene concentrations in soil and groundwater have not been reduced to below the site-specific protection standards (PSs) developed in the draft final CMS (TetraTech NUS, 1998). Therefore, continued bioventing operation with annual system monitoring and testing is recommended until respiration rates and soil gas contaminant concentrations approach asymptotic levels. Parsons ES will evaluate confirmation soil and groundwater sampling results against site-specific PSs that were presented in the CMS and prepare a results report for Spill Site No. 1. When complete, Parsons ES will provide AFCEE and Eaker AFBCA with the draft confirmation soil and groundwater sampling report for review and comment. If you have any questions or require additional information, please contact either Dave Teets at (406) 254-6533 or myself at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

John Ratz, P.E.
Project Manager

Attachments: Figure 1, Tables 1 and 2

cc: Major Ed Marchand, AFCEE/ERT (3 copies)
Mr. Dave Teets, Parsons ES-Billings (1 copy)
Mr. Lee Gorday, Parsons ES-St. Louis (1 copy)
File 727876.68410.E

REFERENCES

Halliburton NUS (HNUS). 1990. *Installation Restoration Program (IRP) Site Investigation, Eaker Air Force Base, Arkansas.*

HNUS. 1997. *Final RCRA Facility Investigation Report, Eaker Air Force Base, Arkansas.*

Parsons Engineering Science, Inc. (Parsons ES). 1996. *Interim Bioventing Pilot Test Results Report for Spill Site No. 1, Building 457 Area, and UST 702, Eaker Air Force Base, Arkansas*. August.

Parsons ES. 1997. Letter Report Summarizing Bioventing System Monitoring at Spill Site No. 1, Building 457 Area, and UST 702, Eaker Air Force Base, Arkansas. October 1.

Parsons ES. 1998. *Final Confirmation Sampling and Analysis Plan for Spill Site No. 1, Eaker Air Force Base, Arkansas*. July.

TetraTech NUS (formerly HNUS). 1998. *Draft Final Corrective Measures Study, Eaker Air Force Base, Arkansas*. August.

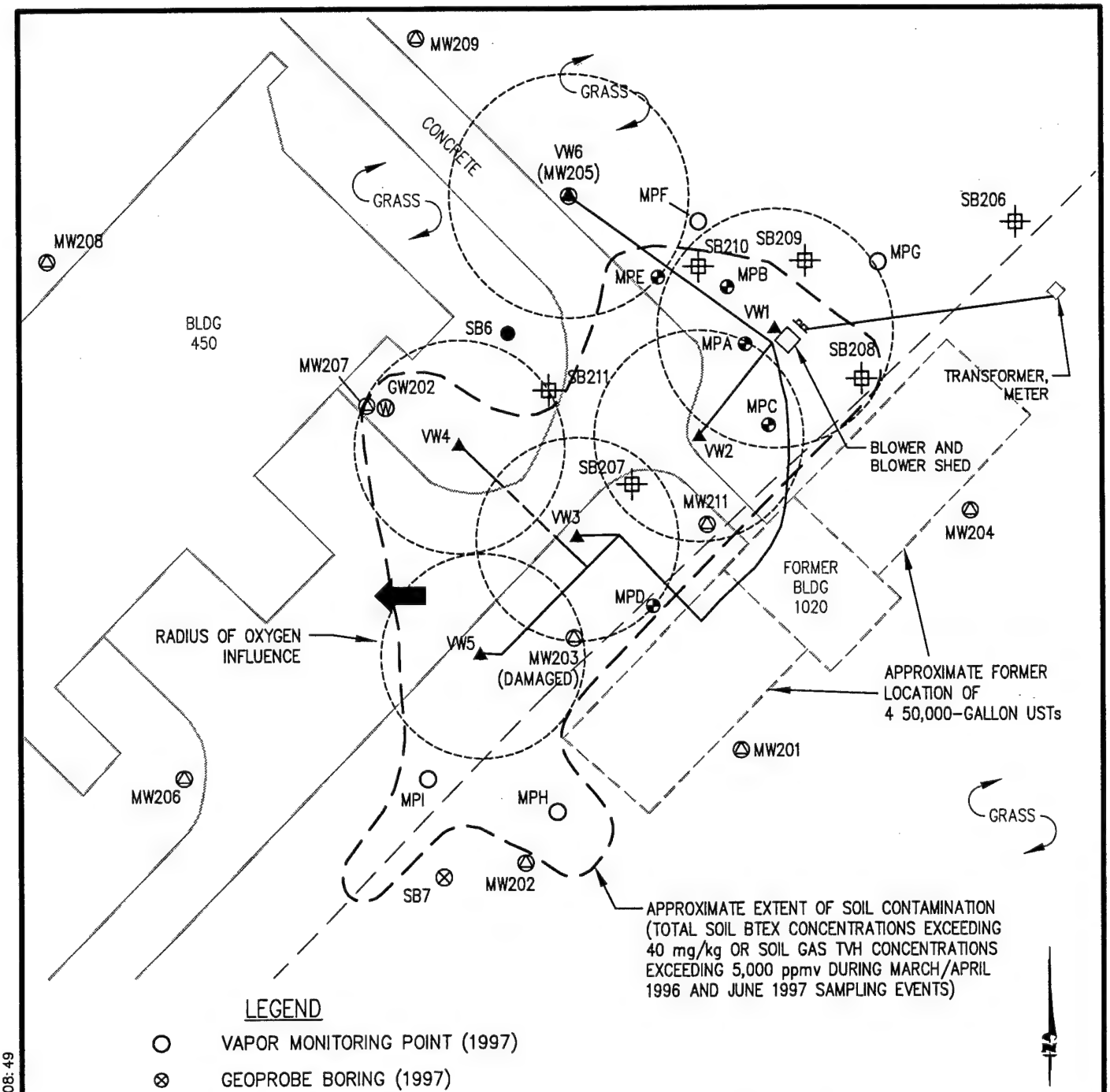

FIGURE 1

SPILL SITE NO. 1
LAYOUT

Eaker AFB, Arkansas

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

S:\ES\cad\AFCEE\726876\98DN1219.dwg, 12/14/98 at 08:49

TABLE 1
INITIAL, 1-YEAR, AND 2-YEAR SOIL GAS FIELD SCREENING AND LABORATORY ANALYTICAL RESULTS
SPILL SITE NO. 1
EAKER AFB, ARKANSAS

			Field Screening Data			Laboratory Analytical Data[a/]				
Sampling Location	Screen Depth (feet bgs)[c/]	Sampling Event[d/]	Oxygen (percent)	Carbon Dioxide (percent)	TVH[b/] (ppmv)[e/]	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
VW1	4-14	Initial	2.5	8.7	>20,000 [f/]	---- [g/]	----	----	----	----
		1-Year	----	----	----	----	----	----	----	----
VW2	4.5-14.5	Initial	0.0	17.0	>20,000	60,000	670	190	120	120
		1-Year	17.8	0.7	760	----	----	----	----	----
		2-Year	13.3	5.1	70	----	----	----	----	----
VW3	4.5-14.5	Initial	0.0	19.0	>40,000	32,000	230	110	51	25
		1-Year	17.5	2.1	220	----	----	----	----	----
VW4	5-20	Initial	1.5	17.0	>40,000	22,000	100	130	58	71
		1-Year	20.2	1.0	42	----	----	----	----	----
VW5	4.5-14.5	Initial	20.8	0.4	260	----	----	----	----	----
		1-Year	16.9	6.2	380	----	----	----	----	----
VW6 (MW205)	9.1-19.1	Initial	3.2	19.0	>40,000	17,000	74	160	51	44
		1-Year	2.5	10.2	370	----	----	----	----	----
		2-Year	3.3	0.2	20	----	----	----	----	----
MPA	9	Initial	1.4	15.0	>20,000	5,900	43	48	24	50
		1-Year	3.4	1.0	14,400	2,000	<0.22 [h/]	0.95	1	11
		2-Year	3.6	8.2	8,600	560	3.8	4	2.6	5.4
MPB	5	Initial	20.4	0.1	2,000	----	----	----	----	----
		1-Year	0.9	5.0	6,800	----	----	----	----	----
		2-Year	17.3	2.7	38	1.3	0.0024J [i/]	0.0072J	0.0085J	0.023

TABLE 1 (continued)
INITIAL, 1-YEAR, AND 2-YEAR SOIL GAS FIELD SCREENING AND LABORATORY ANALYTICAL RESULTS
SPILL SITE NO. 1
EAKER AFB, ARKANSAS

			Field Screening Data			Laboratory Analytical Data[a/]				
Sampling Location	Screen Depth (feet bgs)[c/]	Sampling Event[d/]	Oxygen (percent)	Carbon Dioxide (percent)	TVH[b/] (ppmv)[e/]	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
MPB	8.5	Initial	0.8	15.2	>20,000	6.6 [j/]	0.024 [j/]	0.07 [j/]	0.031 [j/]	0.27 [j/]M[k/]
		1-Year	1.2	5.0	6,400	5,700	1.2	17	7.4	41
		2-Year	5.8	3.8	85	86	0.4	0.72	0.75	1.5
MPC	5	Initial	20.5	0.7	4,200	----	----	----	----	----
		1-Year	14.2	6.0	26,000	12,000	12	19	20	140
		2-Year	15.0	6.1	110	84	0.087J	0.14	0.41	1.8
MPC	9	Initial	2.2	12.1	>20,000	16,000	110	87	51	50
		1-Year	Purged water			----	----	----	----	----
		2-Year	0.8	>25	2,000	3,600	14	10	20	79M
MPD	5	Initial	Purged water			----	----	----	----	----
		1-Year	2.8	15.8	>40,000	----	----	----	----	----
		2-Year	0	>25	>20,000	3,700 [l/]	13.5M[l/]	13.5 [l/]	8.25 [l/]	17M [l/]
MPD	9	Initial	1.5	14.2	>20,000	20,000	63	92	39	11
		1-Year	3.0	5.0	10,000	7,400	22	12	13	16
		2-Year	0.7	15.2	>20,000	9,900	53	58	34	80
MPE	9.5	Initial	1.3	15.2	>40,000	1,600 [j/]	34 [j/]	140 [j/]	39 [j/]	42 [j/]
		1-Year	2.0	5.2	6,000	44,500 [l/]	59 [l/]	130 [l/]	45.5 [l/]	225 [l/]
		2-Year	0.0	16.7	1,900	1,200B	3.4	11	20	26
MPF	8.5	1-Year	0.0	5.0	1,600	1,400	4.6	4.9	0.35	1.2
		2-Year	1.2	5.6	58	----	----	----	----	----
MPG	6	1-Year	0.0	4.8	200	----	----	----	----	----

TABLE 1 (continued)
INITIAL, 1-YEAR, AND 2-YEAR SOIL GAS FIELD SCREENING AND LABORATORY ANALYTICAL RESULTS
SPILL SITE NO. 1
EAKER AFB, ARKANSAS

			Field Screening Data			Laboratory Analytical Data[a/]				
Sampling Location	Screen Depth (feet bgs)[c/]	Sampling Event[d/]	Oxygen (percent)	Carbon Dioxide (percent)	TVH[b/] (ppmv)[e/]	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
MPH	8	1-Year	0.0	9.0	>40,000	68,000	200	91	34	110
		2-Year	0.0	19.0	>20,000	----	----	----	----	----
MPI	8	1-Year	0.2	10.8	>40,000	54,000	150	77	31	140 M
		2-Year	0.0	20.0	>20,000	----	----	----	----	----
MW201	7-22	Initial	9.1	8.0	1,000	----	----	----	----	----
		1-Year	8.7	7.0	94	----	----	----	----	----
		2-Year	10.0	10.1	46	----	----	----	----	----
MW202	6.6-21.6	Initial	8.5	4.3	4,800	----	----	----	----	----
		1-Year	Purged water			----	----	----	----	----
		2-Year[m/]	20.8	0.1	5	----	----	----	----	----
MW203	6-21	Initial	4.2	11.2	>10,000	----	----	----	----	----
(Damaged)		1-Year	1.0	15.0	>40,000	----	----	----	----	----
		2-Year[m/]	19.6	2.8	100	----	----	----	----	----
MW204	NA	Initial	19.8	1.6	150	----	----	----	----	----
		1-Year	15.9	4.0	90	----	----	----	----	----
		2-Year	20.8	0.1	10	----	----	----	----	----
MW206		1-Year	20.8	0.05	0	----	----	----	----	----
MW207	11.5-21.5	Initial	0.0	12.0	6,000	----	----	----	----	----
		1-Year	0.4	10.9	4,800	----	----	----	----	----
		2-Year	8.1	16.0	6,000	----	----	----	----	----

TABLE 1 (continued)
INITIAL, 1-YEAR, AND 2-YEAR SOIL GAS FIELD SCREENING AND LABORATORY ANALYTICAL RESULTS
SPILL SITE NO. 1
EAKER AFB, ARKANSAS

			Field Screening Data			Laboratory Analytical Data[a/]				
Sampling Location	Screen Depth (feet bgs)[c/]	Sampling Event[d/]	Oxygen (percent)	Carbon Dioxide (percent)	TVH[b/] (ppmv)[e/]	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
MW211	9-19	Initial	18.9	2.3	>10,000	----	----	----	----	----
		1-Year	Purged water			----	----	----	----	----
		2-Year	20.4	0.4	1,200	----	----	----	----	----

[a/] Laboratory analysis of soil gas performed using USEPA Method TO-3. Laboratory TVH are C5+ hydrocarbons referenced to jet fuel (MW=156).

[b/] TVH = total volatile hydrocarbons.

[c/] bgs = below ground surface.

[d/] Soil gas sampling performed in March 1996 (initial event), June 1997 (1-year event), and September 1998 (2-year event).
Initial soil gas samples were collected prior to bioventing system startup.
One-year and 2-year soil gas samples were collected approximately 1 month following blower shut down.
The blower operated almost continuously from April 1996 until May 1997, from June 1997 until September 1997, and from November 1997 until August 1998.

[e/] ppmv = parts per million, volume per volume.

[f/] > = denotes field measurement greater than maximum meter reading.

[g/] ---- = not analyzed.

[h/] < = compound analyzed for, but not detected. Number shown represents the sample quantitation limit.

[i/] J = compound detected above method detection limit and less than practical quantitation limit. Reported concentration is a laboratory estimate.

[j/] Laboratory result is suspect based on field soil gas measurements and/or soil analytical results.

[k/] M = reported laboratory value may be biased due to apparent matrix interferences.

[l/] Average of the primary and duplicate laboratory sample results.

[m/] Field result is suspect based on previous field soil gas measurements and on well conditions (i.e., possible air leakage during sampling).

TABLE 2

INITIAL, 1-YEAR, AND 2-YEAR RESPIRATION AND FUEL BIODEGRADATION RATES

SPILL SITE NO. 1

EAKER AFB, ARKANSAS

Sampling Location-Depth (feet below ground surface)	Initial (March 1996)		1-Year (June 1997)		2-Year (September 1998)	
	O_2 Utilization Rate (K_o) (% O_2/hour)	Biodegradation Rate[a/] (mg/kg/year)[b/]	O_2 Utilization Rate (K_o) (% O_2/hour)	Biodegradation Rate[a/] (mg/kg/year)	O_2 Utilization Rate (K_o) (% O_2/hour)	Biodegradation Rate[a/] (mg/kg/year)
VW2-4.5-14.5	0.97	980	NM[c/]	NC[d/]	NM	NC
MPA-9	1.08	1,100	1.30	1,300	0.25	250
MPB-8.5	1.10	1,100	1.16	1,200	0.44	440
MPC-9	1.25	1,300	NM	NC	2.64	2,700
MPD-9	1.11	1,100	2.68	2,700	2.92	2,900
MPE-9.5	NM	NC	NM	NC	1.06	1,100

[a/] Assumes a soil moisture content equal to 17 percent (moisture content at confirmatory boring CBA at 8 feet bgs), and a soil porosity of 0.35.

[b/] Milligrams of petroleum hydrocarbons per kilogram of soil per year.

[c/] NM = not measured.

[d/] NC = not calculated.